Engineering Supply Management System

The Next Generation

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LMI

Executive Summary

ENGINEERING SUPPLY MANAGEMENT SYSTEM

The Next Generation

The U.S. Army Engineering and Housing Support Center (USAEHSC) is modernizing the Facility Engineering Supply System (FESS) used by those Directorates or Divisions of Engineering and Housing (DEHs) that managed real property maintenance supplies in house. The decision to upgrade FESS is based on the inability of the software to satisfy current system requirements, high yearly maintenance costs, and outdated system hardware.

We found that the lowest life-cycle-cost alternative for modernizing the FESS is to modify an existing personal computer (PC)-based system already owned by the Army, or if identified candidates cannot be cost-effectively modified in accordance with standard Army multicommand management information system requirements, to develop an entirely new system. The additional costs to procure and license an existing private-sector system far exceed any functional advantages and any alternative that moves or upgrades existing FESS software to different computer hardware is not cost-effective. Adopting a PC-based system has the added benefit of improved system expandability, flexibility, and better control.

We recommend that USAEHSC take the following actions to minimize the life-cycle costs of implementing the next-generation supply management system used by DEHs.

- Adapt an existing PC-based supply management system or, if acquiring an existing system proves impractical, develop a comparable system that is compatible with UNIX and disk operating system environments, supported by a relational-type database and standard query language, and written in a fourth-generation programming language. Based on our initial investigations, the Corps of Engineers Computer-Aided, Supply Transaction, Logistics Environment appears to be an example of an existing system that USAEHSC could modify.

- Complete a detailed requirements analysis of the proposed system to ensure that the next-generation system fully supports the Army's needs, design and program the system, and implement it in a timely manner to minimize costs.

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CHAPTER 1

INTRODUCTION

BACKGROUND

Materials and equipment used for real property maintenance activity (RPMA) work, which includes construction, maintenance, and repair, are for the most part, peculiar to the Directorates or Divisions of Engineering and Housing (DEH) and are required in sufficient on-hand quantities to ensure responsiveness to the DEH's primary mission. As a result, DEHs procure and store their own inventories of RPMA materials and equipment at DEH-controlled warehouses, shops, and self-help centers.[1] Most RPMA materials are procured through the Government's wholesale supply system or by local purchases. More than 10 years ago, DEHs around the world began using an automated information system called the Facility Engineering Supply System (FESS) to help manage their supplies. FESS is still fully operational and considered by many in the field to be a useful DEH automated system.

Facility Engineering Supply System Configuration

The FESS is an automated inventory control and supply management system that improves material security, reduces the need for manual stock control, simplifies financial accounting, and accumulates necessary management information for periodic reporting. The nature of supply operations in today's Army precludes stand-alone systems. Therefore, over the past 10 years FESS has been upgraded to interface with a number of Army and DoD automated systems. For the most part, these interfaces are accomplished by batch processing on magnetic tape transfers. For example, FESS has a batch interface to the Standard Army Intermediate Level Supply (SAILS) system for Army stock fund accounting requirements, with the Integrated Facilities System-Increment I (IFS-I) for job order accounting and scheduling, and with the Standard Army Financial System (STANFINS) for finance and accounting. Each of these other systems is currently being considered for

[1]DEHs at Army Materiel Command (AMC) installations normally operate under a central supply concept implemented by the Directorate of Logistics (DOL) and therefore are customers of the installations' supply activities.

modification and will be replaced or upgraded in the near future. As a result, if FESS continues to be the DEH's automated supply management system, it will need to be reprogrammed to support continued information exchange with these other systems.

The FESS contains over 200 files and 150,000 lines of code. About 60 percent of the FESS software is written in a Motorola proprietary programming language called VISION, the remainder is programmed in common business oriented language (COBOL). The current FESS is an on-line system and is supported by a custom database. In its current configuration, it and the Motorola IV Phase minicomputer support more than 30 work stations networked in a distributed configuration and handle between 200 and 2,000 transactions a day – depending on location. In order to keep FESS up to date, the Army spends over $500,000 a year on software maintenance alone.

The FESS still runs on its original computer platform, the Motorola IV Phase minicomputer. Over the past 10 years, the IV Phase computer's role has expanded because other systems have been added to the platform such as the Facilities Engineering Job Estimating (FEJE) system and the Integrated Facilities Data Entry Process (IFDEP), a front-end data-loading system to the IFS. As a result, FESS had to share processing time with those other systems. The IV Phase computer has 1.5 Mbytes of memory and can support fixed-storage drives ranging from 67.5 to 570 Mbytes. The U.S. Army Engineering and Housing Support Center (USAEHSC) currently spends about $1.8 million a year through a third-party contract to maintain the Motorola IV Phase hardware. The current contract expires in September 1994.

IFS-M Architecture

The USAEHSC is currently implementing the DEH's new RPMA management system, Integrated Facilities System-Mini/Micro (IFS-M). IFS-M will act as a common hardware/software platform upon which RPMA information systems, including supply management, can operate as stand-alone systems. At the same time, because of the ease of intersystem communications, IFS-M can interface with all other DEH applications. Systems such as IFS-I, FEJE, and IFDEP will no longer be stand-alone when IFS-M is deployed since the functions these systems support will be programmed into IFS-M. IFS-M's system architecture was designed for flexibility and is currently capable of boundless future expansion.

Because IFS-M will contain the DEH's database of record, it is important to recognize the system's architecture since the supply system will essentially operate within IFS-M's system framework. Originally, the fully deployed IFS-M system was intended to include a new supply management system module (or an interface with a redesigned FESS) that was to be fully integrated into all of IFS-M's other modules. However, fresh ideas and lack of resources have precluded the full development of such a module.

Since some information contained in IFM's databases must be shared with other Army and DoD systems, a number of required FESS interfaces have already been written for IFS-M. This means that the new automated supply system can simply use IFS-M as its gateway to these other systems, which would significantly reduce the time necessary to continually program duplicate interfaces.

The IFS-M runs on the Sperry 5000-series minicomputers and is programmed in ORACLE, a fourth-generation language (4GL) supported by a relational database that is standard query language (SQL)-compatible. By "relational" we mean a series of two-way tables that can be easily linked together in an infinite variety of data relationships, allowing maximum information flexibility and accessibility. SQL is the accepted national standard (and fast becoming the Army standard) for accessing data in a relational database, which once written, can be used on any hardware and any relational database software. Systems that do not comply with this requirement or are not planned for this future enhancement will not be considered further. It is essential that systems interfacing with IFS-M operate in a UNIX or disk operating system (DOS) environment.

PROBLEM STATEMENT

Recently, FESS has been criticized because it is over 10 years old, is expensive to maintain, needs functional upgrades to fully satisfy users' needs, and is unable to take advantage of software and hardware technology that can now make system improvements possible at relatively low cost. In response to that criticism, USAEHSC assembled a team of technical and functional supply management professionals to redesign and improve FESS. Following the same development methodology used to create IFS-M, the team used a structured systems requirements analysis to model the next-generation, DEH, automated supply management system. The team identified more than 20 areas in which FESS could be improved, developed

a conceptual data model of the proposed system, and specified the system's detailed requirements. At the time, the team recognized that even the 20 improvement opportunities did not fully identify all needed enhancements. The projected cost to totally redesign and reprogram FESS prompted USAEHSC to investigate other appropriate and cost-effective strategies that would generate the same proposed supply system modeled during the detailed requirements analysis. It arrived at four alternatives: designing and programming a new automated supply management system from scratch, porting and upgrading existing FESS software to a new hardware platform, upgrading FESS on its existing hardware, and modifying/upgrading an existing automated supply management system previously developed by another Government agency or a private-sector company.

STUDY APPROACH

The Logistics Management Institute (LMI) was tasked to evaluate USAEHSC's four options. LMI identified and analyzed automated supply management systems used by the other Services and Government agencies, while the Construction Engineering Research Laboratory (CERL) conducted research into private-sector systems. So that the results of the two separate studies would be comparable, CERL used LMI's systems evaluation methodology as discussed below.

The goal of this study is to determine the least-cost solution to USAEHSC. We analyzed the existing systems that come closest to satisfying the DEH's supply management requirements to determine whether modifying an existing system would be more cost-effective than modifying FESS or programming from scratch. The decisions are based on a least-cost determination of the alternatives' life cycles. We determined how well the existing systems comply with the proposed system's requirements and what it would cost to modify them to make them comply fully. The cost to implement and maintain the proposed systems was added to the modification cost to obtain a total life-cycle cost.

To calculate the life-cycle costs of modifying existing systems, we started with the set of well-defined detailed system requirements produced by a team of Army technical experts, functional experts, and installation-level users. We divided the requirements into functional and technical requirements and then further divided them into meaningful categories to establish an organized list of system requirements. Because each unique requirement is not equally important to the

overall success of the proposed system, the requirements were weighted according to their relative importance. The technique used to compute the relative importance of each requirement is called the analytic hierarchical process (AHP). In that process, opinions and judgments are solicited from a group of experts and the results are quantified using a series of mathematical algorithms. We used the AHP technique at a conference conducted at LMI with a team of Army experts. A software package called "Expert Choice," which incorporates the AHP, was used to facilitate the procedures. When the process was complete, the team had determined relative weights – totaling 100 percent – for both the list of technical and functional system requirements. Some of these requirements were considered so important that if the candidate system could not satisfy them, it would no longer be considered a candidate; those criteria were given an "infinite" weighting. The weighted list of requirements then became the "yardstick" that could be used to measure how well existing supply management systems met the proposed system's requirements. Appendix A describes each of the functional and technical criteria as we interpreted them for this study.

After the list of system requirements had been ranked, LMI identified existing supply management systems from the Navy, Air Force, Defense Logistics Agency (DLA), the Army Corps of Engineers, and the AMC. Meanwhile, the CERL concentrated on the private-sector candidates. Since it was unlikely that any single system would comply totally with all requirements, each candidate's compliance was measured on a 0 to 5 scale[2]. Of the systems we evaluated, those with the highest aggregate weighted scores were considered the strongest contenders, and we analyzed them for life-cycle costs. The final selection of all the candidate systems was based on lowest life-cycle costs which were then compared to the other alternatives – upgrading FESS on its existing platform or porting FESS to new hardware. The weights assigned for each requirement are shown in Table 1-1.

REPORT ORGANIZATION

The remainder of this report provides the results from our analysis of the alternatives. Chapter 2 gives a brief description of each of the existing Government and private-sector candidate systems and provides a summary of the results of the technical and functional evaluations. A brief description of the proposed functional

[2]The following interpretation of the scores was used: 5 = complies totally, 4 = complies very well, 3 = complies fairly well, 2 = complies poorly, 1 = does not comply or cannot comply.

TABLE 1-1

SYSTEM REQUIREMENTS

Technical criteria	Weight (percent)	Functional criteria	Weight (percent)
On-line capability	∞[a]	Report generating and printing capabilities	0.035
Required database management system		Stock control requirements	
Relational database/SQL	∞	Expanded item identification	0.022
System files maintenance	∞	Stock fund war reserves/freeze codes	0.010
Ease of use/self-help capability	0.143	Catalog file	0.114
Canned queries	0.011	Replenishment capability	0.093
Documentation	0.033	Add/drops	0.021
System independence	0.071	Physical inventory requirements	
System security	0.024	Cyclic inventories	0.003
Distributed configuration	∞	Inventory worksheet	0.025
Required interfaces		Line-item/dollar-value accounting	0.028
IFS-M	∞	Seasonal/standby items	0.013
SAACONS	0.048	Spoilage/aging inventory display	0.003
Other supply information	0.019	Picking/issuing requirements	
SAILS/SARSS	0.007	Creates pick documents	0.007
Finance and accounting	0.136	Automatic material coordination and equipment control	0.028
Platform independence	0.368	Automated issue/return slips	0.052
Scanning capabilities		Determining picking criteria	0.003
Bar-code inputs	0.028	Receiving/putaway requirements	
Optical scanning equipment	0.028	Generating storage documents	0.011
Imaging	0.083	Hot tag (receipt/issue)	0.010
		Partial receipts	0.018
		Automatic inventory update	0.048
		Discrepant material	0.004
		Order processing requirements	
		Transaction reversal capability	0.012
		Document register	0.006
		MILSTRIP procedures	0.052
		Transaction register	0.024
		Automatic purchase requisitions	0.063
		Reconciliation	0.009
		Job cost by document, phase, and/or facility	0.288
Total	1.000	**Total**	1.000

***Note*.** SAACONS = Standard Army Automated Contracting System. MILSTRIP = military standard for requisitioning and issue procedures. SQL = Standard Query Language. SARSS = Standard Army Retail Supply System.

[a] Infinitely weighted criteria, e.g., essential criteria that must be met.

and technical system requirements is presented in Appendix A, and the detailed results of the evaluations are provided in Appendix B. Chapter 3 provides the results of the life-cycle cost comparisons of modifying the existing systems, upgrading and porting FESS to new hardware, programming an entirely new system, and upgrading FESS on its existing hardware. Appendix C provides the detailed results from this analysis. In Chapter 4, we provide our conclusions from the research together with our recommendations for USAEHSC.

CHAPTER 2

FUNCTIONAL EVALUATION OF CANDIDATE SYSTEMS

Our search for viable candidates from other Government agencies identified about 20 supply management systems. We reduced the field of viable candidates to 10 after eliminating systems that were near the end of their useful system life, that did not possess required functionality, or that did not comply with one or more of the infinitely weighted criteria. We excepted several mainframe systems that did not meet the infinitely weighted criteria; we considered them further because of their very strong functional compliance and because they provided a baseline for comparisons against the other systems. The supply management systems described below survived the initial screening process and comprise the set of viable candidate systems.

The set of potential supply management systems from the private sector was much larger. An automated and manual search (conducted by CERL) identified over 1,400 candidate systems. However, after screening those systems for compliance with the infinitely weighted criteria, the number of candidates was reduced to a more manageable 19 systems. Any one of those 19 systems could be made to satisfy all the requirements, and the vendors were willing to respond to proposals to modify the systems; however, only the top 6 private-sector systems are discussed below.

GOVERNMENT SYSTEMS

Standard Base Supply System

The Air Force's Standard Base Supply System (SBSS) is an automated management system that has been in operation since 1964. It runs on UNISYS 1100-series (soon to be upgraded to 2,400 series) mainframe computers and is programmed in COBOL (version 1974, soon to be upgraded to the 1985 version). The system batch processes the base supply information and is not supported by a true relational database or SQL. We also found that the system is not very user friendly compared to other systems and requires some knowledge of programming languages to make ad hoc queries of the database. Upon initial inspection, SBSS appeared a strong candidate, but after more careful analysis, we found the system did not comply with

many of the proposed technical requirements and it was dropped from further consideration.

Civil Engineering Material Acquisition System

The Civil Engineering Material Acquisition System (CEMAS) was developed for the Air Force Base Civil Engineer (BCE) to support cost-effective acquisition of maintenance and repair materials from Government and commercial warehouses. CEMAS runs on the BCE's Wang minicomputer and does not operate in a UNIX or DOS environment. Although CEMAS satisfies many of the functional supply management requirements specified by the Army, it is not supported by a relational database nor SQL and does not run in a distributed configuration environment.

Medical Stock Control System

The Medical Stock Control System (MEDSTOC) is an automated system developed by the Army Health Services Command (HSC) to support supply management. MEDSTOC runs at the Army's regional data centers on Amdahl mainframe computers and must be accessed through the Army Standard Information Management System (ASIMS) network. MEDSTOC batch processes information and is not supported by a relational database or SQL. We found that MEDSTOC was not as user friendly as other systems we examined, but it did perform many of the functional requirements. MEDSTOC is currently undergoing system modifications by the HSC.

Warehouse Inventory Control System

The Warehouse Inventory Control System (WIS) is an on-line automated supply management system written in dBASE III PLUS (a 4GL). WIS was developed by the U.S. Army Corps of Engineers Portland District to support its local needs. Currently, WIS is not configured to run in a distributed environment but can easily be made to do so. WIS can run on IBM-compatible personal computers (PCs) on any DOS environment. It is easy to use but does not have an extensive self-help capability. Although WIS was designed as a supply management system, it does not possess as much functionality as other systems we considered. However, because it is written in a 4GL, it can easily be made to comply with any of the system requirements.

Army Materiel Command Installation Supply System

The AMC Installation Supply System (AMCISS) is the AMC's installation-level automated supply management system. It is written in COBOL 1974 American National Standards Institute (ANSI)-standard which makes it highly dependent on the Amdahl/IBM 3090 hardware running at the Army's Regional Data Center. AMCISS runs under the MVS/CICS operating system and is a centralized processing system that runs on-line through remote terminals via ASIMS. The database is custom designed and is not relational and not SQL-compatible (it also uses a custom-designed query language). Although AMCISS does not pass the technical criteria on several counts, we felt it deserved a closer look for several reasons. First, it satisfied the functional requirements as well as any of the other systems we analyzed. Second, AMC is considering developing a corporate database into which AMCISS information would be entered nightly. Third, AMC is developing PC downloading utilities, which will give AMCISS a distributed configuration capability. Finally, AMC is considering converting to COBOL II programming and reverse engineering the system to reduce the quantity of code (approximately 1.5 million lines), actions that would greatly enhance the system's portability to other hardware platforms.

Automated Personal Property Management System

The Automated Personal Property Management System (APPMS) is the new property book management system used by the Army Corps of Engineers. The system was developed by a contractor out of the Portland District and will soon become the Corps' standard property book management system. Although from a functional point of view, APPMS is not a good supply management system, it has a good technical system configuration: APPMS is written in FOXBASE+ (a 4GL), which is fully compatible with a relational database and SQL; it is a PC-based system that runs on DOS 3.1 or better; it is capable of local and wide area networking on NOVELL systems; and it is an on-line system that is user friendly with an interactive help capability. FOXPRO allows great flexibility in ad hoc queries (sorts and searches) and report generation although APPMS already has a number of useful canned queries programmed. APPMS does not currently have import/export routines built into the system because it does not need them for its current purpose, but its relational database and SQL capabilities make construction of any required interfaces relatively easy.

Electronic Point of Sale

The Naval Supply Systems Command has implemented the Electronic Point-of-Sale (EPOS) supply management system at a number of Naval Supply Centers to take advantage of the latest PC networking technology and needed supply management improvements. EPOS was developed by a private-sector contractor and implemented as a turnkey system. It was programmed in "C" language [a third-generation language (3GL)] and uses the C-Tree database system, which is fully relational. EPOS fully utilizes bar-code technology as its primary form of system inputs. It is an on-line, real-time system and is easy to use, but it has limited self-help capability. Functionally, it complies well with the requirements and already has programmed most of the canned reports. However, its ad hoc query capability is difficult to use. Either a knowledgeable C programmer must create the query or the database must be converted to American Standard Code for Information Interchange (ASCII) text and transferred to a database system known to the user and then manipulated to generate the required reports. The system already has a number of interfaces written to the Navy's finance and accounting, contracting, and wholesale supply system, but they would not meet the Army's interface needs.

Computer-Aided Supply Transactions, Logistics Environment

The Computer-Aided Supply Transactions, Logistics Environment (CASTLE) is an automated, on-line, distributed system developed by the Army Corps of Engineers New Orleans District to manage inventory at its supply stores. CASTLE is written in dBASE III PLUS for a PC network environment, operates through DOS, and is therefore free to move to a number of different platforms. The dBASE III PLUS closely resembles hierarchical databases although it is not currently SQL-compatible (future versions of dBASE software will be SQL-compatible). We found CASTLE to be functionally adequate, user friendly, and well supported by pop-up, self-help menus. Since it is a 4GL system, any deficiencies can easily be overcome through programming.

Base Operations Support System

The Base Operations Support System (BOSS) runs on an IBM mainframe computer (MVS operating system). It is used by the DLA to manage inventory that supports all base operations. BOSS is written primarily in COBOL language, is an on-line system, but is not supported by a relational database or SQL. BOSS has code

written to make it operate like a distributed configuration. It is not as user friendly as some other systems we examined but is supported by some self-help screens.

Standard Army Retail Supply System

The Standard Army Retail Supply System (SARSS) is the Army's new real-time, retail-level supply management system that will replace the SAILS system, a batch processing system. SARSS automates requisitioning, receipt, issue, and storage of Army materials at the retail level and was implemented to improve responsiveness of all aspects of supply operations. SARSS was designed to operate from the direct support unit through the theater or major command level in both the tactical- and installation-type organizations. However, implementation of an installation-level baseline will not occur until 1993, at the earliest. The SARSS Branch of the U.S. Army Combined Arms Support Command (CASCOM), Deputy Chief of Staff for Logistics, developed and is responsible for maintaining SARSS.

The SARSS is a multilevel system that divides the needed functionality between several supporting tiers of operation. In the tactical environment, it is written in standard COBOL for Burroughs tactical minicomputers. At the Corps level, it is predominantly written in INFORMIX, a fully relational 4GL database language supported by SQL, and is designed to run on the Sperry 5000-series minicomputer. The installation-level system, when completed, will pull much of its needed functionality from these existing levels and will be written in INFORMIX. However, to satisfy the current needs of the DEHs, USAEHSC will have to modify SARSS in its current form, which means that the needed functionality written in COBOL will have to be reprogrammed in INFORMIX. Otherwise, USAEHSC will have to wait until the installation baseline is completed.

PRIVATE-SECTOR SYSTEMS[1]

Argos Business Enterprise Cost Accounting System

The Argos Business Enterprise Cost Accounting System (ABECAS) is programmed by Argos Software and is a modular financial and management accounting system that allows the users to select their needed functionality. The

[1]This section is taken from a report by the U.S. Army Construction Engineering Research Laboratory, *Facilities Engineer Supply Management System Survey*. Patrick Tanner and Don Hicks. August 1991.

system's modules that support the DEH's needs are the Sales Order Processing, Register Sales, Purchase Order Processing, Inventory Management, Accounts Receivable, Accounts Payable, General Ledger, and Database Query modules. ABECAS operates on all IBM-compatible PCs and is capable of local area networking.

FOURGEN Accounting System

The FOURGEN Accounting System is a modular accounting and distribution system that satisfies many of the DEH's supply management system requirements. For instance, USAEHSC would have to procure the Order Entry, Purchasing, Inventory Control, and Utility modules so that the system can satisfy the DEH's needs. FOURGEN is a PC-based system written in INFORMIX, a 4GL language supported by a relational database and SQL.

Macola Accounting and Distribution System

The Macola Accounting and Distribution System (referred as MACOLA in the tables) is a modular inventory control and accounting system developed by Macola, Incorporated. The modules that support the DEH's requirements are the Customer Order, Inventory Management, Purchase Order, Accounts Receivable, Accounts Payable, Query, and System Manager modules. The Macola System is a PC-based system that operates in a DOS environment and can be configured to operate in a local area network.

Information Control System for Manufacturers, Distributors, and Retailers

The Information Control System for Manufacturers, Distributors, and Retailers (referred to as PIC in the tables) is an integrated modular system developed by PIC Business Systems, Incorporated. This system possesses Order Processing, Inventory Management, Purchase Orders, and Systems Utility modules that will support the DEH's requirements. The system is written in a proprietary language that runs on PC platforms and can be configured to operate in a network environment.

Great Plains Accounting Series

The Great Plains Accounting Series System (referred to as PLAINS in the tables) is a set of Accounting, Inventory Control, and Job-costing modules written by

Great Plains Software, Incorporated. The Plains system is written in a proprietary language that operates in a DOS or UNIX environment on PC platforms.

Financials and Distribution System

The Financials and Distribution System (referred to as TECSYS in the tables) performs order entry, inventory management, purchase order, and financial functions. The system was developed by TecSys, Incorporated, and was written in INFORMIX, a 4GL supported by a relational database and SQL, to run in a UNIX environment.

SYSTEMS EVALUATION

We conducted in-depth interviews at working sites, when possible, to determine how well each of the remaining 10 Government candidates complied with the specific technical and functional requirements. If visits to actual working sites were not possible, we conducted telephone interviews and in-depth research into the system's documentation. At the same time, CERL interviewed private-sector companies to determine how well the 6 private-sector candidates complied with the proposed system requirements. Details of the analysis for each of the Government candidate systems are included in Appendix B. Details of the private-sector system scores can be found in the CERL report, *Facilities Engineer Supply Management System Survey.* The results for the 10 Government candidates, the 6 private-sector candidates, and the current FESS are summarized in Table 2-1. A score of 3.5 or greater is satisfactory while a score of 2.5 or below is unacceptable.

Since upgrading FESS and/or porting it to new hardware are also alternative solutions, we examined them in the same level of detail as the other candidate systems. As a result of FESS's current technical deficiencies, it could not pass the proposed technical requirements imposed on the next-generation engineering supply system. However, since FESS represents the status quo, we retained the system for cost analysis.

In general, we found that the three mainframe (MEDSTOC, AMCISS, and BOSS) and minicomputer (CEMAS)-based systems complied well with the functional requirements. However, those same systems satisfied very few of the technical requirements and none fully satisfied all the infinitely weighted criteria. As a result, all these systems failed the technical evaluation part of the study and all should have

TABLE 2-1

SYSTEM COMPLIANCE SCORES

System	Pass/Fail[a]	Technical	Functional
FESS	Fail	1.92	3.68
SBSS	Fail	1.40	–
CEMAS	Fail	2.21	3.79
MEDSTOC	Fail	1.83	3.24
WIS	Pass	3.87	2.57
AMCISS	Fail	1.98	4.26
APPMS	Pass	4.18	2.92
EPOS	Pass	4.25	3.61
CASTLE	Pass	4.47	4.20
BOSS	Fail	1.82	4.19
SARSS	Pass	3.68	3.89
ABECAS	Pass	4.21	4.56
FOURGEN	Pass	4.34	4.28
MACOLA	Pass	4.30	4.40
PIC	Pass	4.41	4.20
PLAINS	Pass	4.20	4.52
TECSYS	Pass	4.67	4.57

[a] Fail indicates the system failed to pass one, several, or all the infinitely weighted criteria

been dropped from further consideration because the costs to make them comply with the technical constraints would be prohibitive. However, both AMCISS and BOSS possessed such high functional scores, they were retained for the sake of comparison.

Both the public- and private-sector PC-based systems that we examined and the SARSS presented an entirely different picture. For the most part, they had average-to-excellent compliance with the functional requirements but very-good-to-excellent compliance with the technical requirements. As would be expected, all these systems performed most of the required inventory control and supply management functions and the deficiencies that existed were the result of unique Government and Army operations. For example, none of the private-sector systems interfaced with the required Government systems, generated the required documents/forms, performed

the required level of job cost control, or ordered materials according to military standard requisitioning and issue procedures (MILSTRIP). However, the deficiencies in all of these systems are such that some reprogramming could enable them to fully satisfy the objectives of the proposed system requirements. Users of the PC-based systems almost unanimously agreed that greater flexibility and better control of system changes and costs were major advantages of those systems.

In part, we used the technical and functional compliance of each candidate system to eliminate potential candidate systems and to reduce them to a manageable number. Of the 10 candidate Government systems that were analyzed for technical and functional compliance with the established requirements, only 7 were considered strong contenders and subjected to the cost analysis. All 6 private-sector systems were carried forward to the cost analysis portion of this study.

CHAPTER 3

COST ANALYSIS

METHODOLOGY

The life-cycle costs of any information system can be divided into the following components: requirements analysis, specification, design, coding, testing, implementation (i.e., integration, fielding, and training), and maintenance (i.e., normal operations, corrections, and upgrades). Since the requirements analysis and specification phases were already complete, we needed to estimate only the costs to modify (to meet the technical and functional requirements of the DEHs), implement the modified system at all DEH sites, and maintain each system for a period of 10 years. Costs were estimated in terms of the number of man-days of effort. Table 3-1 shows a summary of costs for the 13 candidate systems, the cost to develop a new custom system, the cost to port FESS to a PC platform, and the cost to continue using FESS with proposed upgrades.

Many factors were necessarily considered in making estimates for each system. The size of the system affects life-cycle costs, since larger systems are more difficult to develop and maintain. The number of lines of program code, the number of programs or modules, and the size and number of data files used by the system were all considered. In addition, we assumed that systems written in 3GL, such as COBOL, take more time to develop and maintain than systems written in 4GL, such as dBASE III. We also assumed that mainframe systems require even more effort than PC-based systems because of the increased complexity of operating systems and interfaces.

Developing life-cycle cost estimates for any automated system is not an exact science; however, our life-cycle, man-hours-of-effort estimates show relative differences between candidate systems and provide a sound basis on which to make decisions among the various alternatives.

TABLE 3-1

ESTIMATED SYSTEM LIFE-CYCLE COSTS

Candidate system	Modification (man-days)	Implementation (man-days)	Operation and maintenance (man-days)	Total (man-days)
APPMS	457	5,060	7,200	12,717
AMCISS	1,112	10,060	868,448	879,620
BOSS	1,265	10,060	869,060	880,385
WIS	457	5,060	7,200	12,717
CASTLE	145	5,060	7,200	12,405
EPOS	556	5,060	10,800	16,416
SARSS	715	5,060	14,400	20,175
New custom system	3,600	5,060	8,600	17,260
FESS-PC	4,246	5,060	14,400	23,706
FESS-mini	1,144	2,530	80,000	83,674
ABECAS	68	5,060	7,200	12,328
FOURGEN	122	5,060	7,200	12,382
MACOLA	144	5,060	7,200	12,404
PIC	155	5,060	7,200	12,415
PLAINS	84	5,060	7,200	12,344
TECSYS	170	5,060	7,200	12,430

MODIFICATION COSTS

Each candidate system was scored by how well it complied with the established system requirements. Those scores were then used to estimate the number of man-days necessary to modify each system to comply totally with all of the functional and technical requirements. For example, if a candidate received a rating of two for any particular criterion, the number of man-days of programming required to raise the system's rating to a five (total compliance) was estimated for each noncompliant criterion.

The following components were considered in our modification estimates: analysis of the particular system requirement, design of the solution, and coding and testing of the solution. Since all DEHs have common needs, we assumed that all

modifications would be centrally managed. We assumed that modifications to PC systems made after implementation fall under maintenance and that database conversions from FESS to the new system are considered as implementation costs.

Six of the public-sector candidate systems (APPMS, WIS, CASTLE, EPOS, FESS-PC, and new custom system) shown in Table 3-1 are PC-based systems. In general, the costs to modify PC-based systems are lower than those for mainframe systems. The two mainframe systems considered (AMCISS and BOSS) are both 25 years old, are written in COBOL (1974 ANSI standard), contain hundreds of thousands of lines of code, contain dozens of separate programs and data files, and do not use relational database structures. These kinds of mainframe systems are much more difficult to modify than PC-based systems. The cost in time required to prepare and justify system change requests for approval was also added into the estimates. SARSS is a mini-computer-based system, written in a combination of COBOL and INFORMIX (a 4GL and relational DBMS). Its costs will be between those of the PC and the mainframe systems.

Three of the public-sector candidate systems considered in Table 3-1 (APPMS, WIS, CASTLE, and perhaps the new custom system) are written in a 4GL. In general, source code developed in a 4GL requires less development time than source code developed in a 3GL because higher level languages make use of prewritten subroutines, handle system interfaces automatically, have menu-driven commands or command-syntax that looks much like English sentences, and have features that allow them to be used as relatively fast application generators. Also, the fact that 4GLs require fewer lines of code to program a particular function than 3GLs is an obvious advantage.

The modification effort presented in Table 3-1 considers the programming complexity each technical and functional criterion requires. For example, systems that need programming to automate an *item pick documents* feature are relatively complicated because, among other things, special-purpose output forms must be designed and tested. Adding *replenishment capability* is simple by comparison, because it only requires a short programming module that uses relatively few, well-known formulas. However, programming is not a sequential process and economies of scale will definitely be realized. For example, the functional category of *picking/issue requirements* consists of four subfunctions – *create pick documents, automatically coordinate material, automatically issue return slips*, and *determine*

picking criteria – that will probably use many of the same parameters and algorithms, with only slight variations. Therefore, fewer programming hours will be required to make the modifications as a group than to make them individually. By comparison, the *canned queries* and *ease of use/self-help* subfunctions do not offer economies of scale. In several cases, because of economies of scale, we estimated the required man-days for an entire technical or functional criteria set, and not by individual subfunction criteria.

The technical criteria with "infinite" weights do not have man-days of modification associated with them; they are rated either "pass" or "fail" because of the criticality of those criteria. Even though the mainframe systems "failed" the relational database and distributed configuration criteria, we retained them for life-cycle-cost comparison purposes. Also, even though the mainframe systems are not platform independent, we did not include a modification cost to port them to a PC. Such modification costs would be pointless and prohibitively expensive compared to building a new system from scratch. We assumed that they would continue to operate on their current mainframe platforms.

We summarize the total estimated man-days of modification effort for each system in Column 2 of Table 3-1. Appendix C displays our detailed estimates of modification time required by the technical and functional criteria for each public-sector candidate system. The detailed estimates for the private-sector candidates can be found in CERL's final report, *Facilities Engineer Supply Management System Survey*.

Modification estimates for the six private-sector systems (ABECAS, FOURGEN, MACOLA, PIC, PLAINS, and TECSYS) were provided by CERL. Since each of the candidate systems is proprietary, the systems' vendors were given the list of system deficiencies and asked to estimate the level of effort (in man-days) required to program the systems to satisfy the proposed DEH system requirements. The vendors responded with varying levels of detail, but all the estimates were of a similar magnitude.

We found that PC-based systems have lower total modification costs than the mainframe systems even for APPMS and WIS, which need more functional modifications than the mainframe systems. CASTLE and the six private-sector systems require the least amount of modification effort because they have the highest

technical/functional scores, they are PC-based, and they are written in a 4GL. CASTLE was developed in 90 man-days (excluding user-client effort), and the alpha and beta tests were completed within 1 year with a relatively minor number of man-days for corrections/upgrades. The EPOS system will require more programming effort than WIS and APPMS because it is written in a 3GL; however, EPOS is easier to modify than the mainframe systems. Porting FESS to a networked PC system will be the most difficult task because interfaces to the operating systems must be changed and two different coding languages must be converted, in addition to upgrading its functionality. A new custom system will be the next most costly to develop because it must be developed from scratch. Our estimates for developing a new custom PC system assume that it would be programmed in a 4GL and include the effort of user-clients for design and testing, a sometimes hidden design cost already borne by existing candidate systems. The estimates for converting SARSS to a DEH supply system are higher than for the PC systems, since both COBOL and INFORMIX modules would have to be modified.

IMPLEMENTATION COSTS

The following activities were considered in our implementation estimates: centralized creation/modification of system documentation (including users guides), local database conversion from FESS to the new custom system, local system installation, local training, and centralized planning and follow-up for all implementation activities. We assumed 100 separate sites in our estimates. For the PC- and mini-based systems, local installation (including follow-up support) would require about 10 man-days of effort and database conversion would require about 40 man-days of effort. For the mainframe systems, local installation would require about 20 man-days of effort and database conversion would require another 80 man-days of effort. Those estimates came to about 5,000 man-days of effort for PC and 10,000 man-days for mainframe systems implementation. For all candidate systems, an additional 60 man-days of effort was added for the centralized documentation activities, yielding an estimate of 5,060 and 10,060 man-days of total implementation costs for PC and mainframe systems, respectively. Implementation of an upgraded FESS on the existing platform was assumed to be half the cost of implementing a new PC system. These cost estimates are shown in Column 3 of Table 3-1.

OPERATION AND MAINTENANCE COSTS

After new systems have been implemented, maintenance costs begin, and they continue through the operational life of the system. The operational life of any new DEH system is determined by how well the system continues to meet such DEH needs as hardware and software reliability, changes in hardware and software technology, changes to DEH supply management requirements, and system operator and maintenance costs among other needs. It is difficult to select an exact time frame for any new system's life cycle: FESS is over 10 years old and BOSS and AMCISS have lasted 25 years already. However, for purposes of this cost analysis, we selected a 10-year life cycle.

The maintenance phase estimates considered several activities: corrections to software, upgrades to new releases of operating and application-base software (e.g., dBASE, C, COBOL), hardware expansions and upgrades, modification of application software to include new technical or functional capabilities (e.g., multimedia), changes to system interfaces, documentation updates, and time-connect charges and long-distance telephone costs (if any) for mainframe systems. Our estimates assume that the initial system modifications, documentation, and maintenance would be performed centrally. Although local maintenance is an option, not all sites would have the technical capability necessary to make programming and database changes. Furthermore, consistency of the technical and functional quality of the installations would be lost. Therefore, the estimates measure implementation of a compiled version of the software at each site to preclude local system changes. Subsequently, USAEHSC would maintain the system centrally – similar to its current responsibility with FESS – except that maintaining a 4GL system would only require a fraction of the costs of maintaining FESS.

The estimated operation and maintenance costs for each candidate system are shown in Column 4 of Table 3-1. We assumed an average of 10 terminals per installation, an average of $200/month connection charges and long-distance telephone costs per terminal, and 100 installations.

The costs for the mainframe systems are much greater than PC-based systems because of time-connection charges and long-distance telephone costs. Annual system-wide connection charges alone cost $2.4 million. If we assume an average man-year cost of $50,000 fully loaded, this yields 48 man-years or 86,400 "equivalent

man-days" of cost. Over a 10-year life-cycle, this would result in an equivalent 864,000 man-days of effort.

The other maintenance costs for mainframe and PC systems were derived using a multiplicative factor. For a traditional mainframe, 3GL systems studies have shown that maintenance costs normally account for 70 to 80 percent of a system's total life-cycle costs.[1] Since BOSS and AMCISS are more than 20 years old, have not been converted to the latest ANSI standard COBOL, use custom-written and nonrelational databases, and are not SQL compatible, we used the 80 percent figure for a 10-year life cycle. Thus maintenance costs were estimated at four times the modification costs. Similar studies have not yet been widely published for PC systems; however, we assumed they would be cheaper for all of the reasons discussed above. We therefore assumed factors of two and three for PC systems written in 4GL and 3GL, respectively.

For PC-based systems owned by USAEHSC, the multiplicative factor should be applied to the full development cost of those systems. Therefore, given an estimated 3,600 man-days to develop a new custom PC system from scratch in a 4GL, the operation and maintenance effort of the PC-4GL systems over 10 years would be approximately 7,200 man-days. The effort required for the EPOS (3GL system) would be about 10,800 man-days. The maintenance effort shown for FESS is the current contractual maintenance costs converted to man-days.

LIFE-CYCLE COSTS

The total life-cycle costs for 10 years are shown in the last column of Table 3-1. The estimates show that primarily because of lower maintenance costs, any PC system would require much less effort than the mainframe systems and that 4GL systems require less effort than the 3GL systems. In addition, the life-cycle costs of keeping FESS on its existing platform but upgrading its functions were also much higher than the PC systems because it is written in VISION and COBOL and will continue to be difficult to maintain over the next 10 years. Porting FESS to a new hardware platform resulted in lower maintenance effort although the initial modification costs were the highest.

[1]Melior, Page-Jones, *The Practical Guide to Structured Systems Design*, Yourdon Press, Englewood Cliffs, N.J. 2nd edition, 1989. p. 26.

Because the private-sector systems are not already owned by the Government, additional costs will be associated with procuring one. More time will be needed to generate contract specifications, develop a request for proposal, and proceed through the Government acquisition process. In addition, costs will be associated with licensing and acquiring the vendor's source code. CERL investigated those additional costs and found that private-sector companies would be willing to provide source code and licensing for between $1,000 to $6,000 per site ($100,000 to $600,000 total). Each vendor expressed interest in responding to a request for proposals and was willing to sell the source code. It is likely that these quoted prices could be negotiated for less during a competitive procurement.

The total life-cycle costs for a new custom system, private-sector systems, and the 4GL public-sector systems appear to be relatively close. However, Table 3-1 does not reflect the impact of timing (opportunity cost). This is potentially a large cost for those systems that could take up to a year to procure or to modify/develop, test, and implement. During that time, both the current FESS hardware and software would have to be maintained at a rate of $1.5 million for hardware and $0.5 million for software for another year or more. That cost can be avoided since an existing public-sector PC system can be modified and implemented quickly.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

In today's highly dynamic automated systems environment, no computer information system is designed to last indefinitely. New technological advances are made so quickly that existing systems can become obsolete and increasingly difficult to maintain (compared to newer systems) within a matter of years. While the FESS continues to be a useful and popular automated system, it is more than 10 years old and through normal system evolution has entered the last stages of its life cycle. The FESS software alone costs more than $0.5 million a year to maintain, and its hardware platform, the Motorola IV Phase minicomputer, is also dated and costs more than $1.8 million a year; those costs will likely increase in the future. We believe the Army can no longer afford to maintain FESS in its current form and should either replace or upgrade it.

Using FESS's current functionality and proposed improvements to the system as the baseline, the USAEHSC has already decided how the next-generation engineering supply system should function and what technical constraints will support those requirements. Any of the alternatives that upgrade the current FESS software or keep the Motorola IV Phase hardware intact impose unnecessary costs on the Army. Although FESS itself is the basis for the proposed system, it does not fully satisfy all the proposed functional requirements nor the proposed technical system specifications; to make it meet the criteria, some cost-prohibitive modifications would be required. Our analysis demonstrates that, in its current form, modifying FESS in any fashion would not be cost-effective.

For example, since FESS is programmed in VISION and nonstandard COBOL, programming new functional upgrades is more difficult and therefore more expensive than if it were programmed in a current, commercially available 4GL. Furthermore, FESS is not supported by SQL which makes communications to other DEH, Army, and DoD systems more difficult and more expensive. Automated systems supported by SQL greatly simplify the effort required to program new interfaces, which is

particularly important considering the volatile nature of those other systems that FESS must communicate with.

For similar reasons, converting the FESS software to run on other hardware platforms or porting FESS to a new PC platform is also very expensive, if at all possible, given that there has been little success converting 2GL to 4GL. Even when same-generation languages are converted, such conversions often result in numerous program errors which may require more effort to debug than would otherwise be necessary if an entirely new system were programmed in a modern language. Furthermore, simply upgrading the current version of FESS would leave its software and hardware platform in place, would not support the DEH's move toward a more flexible and open systems architecture environment (i.e., the IFS-M platform), and would continue to cost the Army at least $2.3 million per year to maintain.

Since FESS is not a cost-effective starting point (in terms of technology) from which to base the future supply management system, all existing hardware and software must be replaced. Several automated supply management systems from both the private and public sector already exist and comply with enough functional and technical requirements to make them cost-effective replacements even with modification expenses considered. Adapting an existing system will preclude the need for the system design, programming, and alpha and beta testing that would be required for a totally new system and would set back system implementation by about 1 year – time that could be used to implement an existing system. Although programming a completely new system that meets all system requirements is not the most cost-effective alternative from a life-cycle costs basis, USAEHSC should consider this alternative as a second choice if they find that acquiring an existing system is either administratively impossible or impractical.

Given the system configurations of the current hardware (Motorola IV Phase) and software (FESS) and the expected role automation will play in DEH supply management systems, there is no reason to preclude PC-based systems from such consideration. The evidence from the life-cycle costs analysis indicates that PC-based systems written in a 4GL, supported by a relational-type database and SQL, and configured to operate in a network environment will contribute to the DEH's move toward an open system's architecture and will require much less effort to maintain. Also, processing speed and resident memory of PC-based file-server configurations

can easily satisfy both technical and functional requirements of the new system. Fixed storage in today's market is relatively affordable and can be configured to satisfy the 600 Mbytes needed by the current systems although the hardware platform supporting the new supply management system will probably need less fixed storage. In addition, the PC systems are more flexible and expandable and fit in with the DEH information system architecture strategy. Also, given the uncertainty of the future of other Army and DoD systems that interface with the supply management system, the fact that the existing PC-system candidates are all programmed in 4GLs with relational-type databases and SQL greatly reduces the risk and costs associated with these uncertainties.

Further examination of the life-cycle costs shows that the greatest savings were realized during the implementation and maintenance phases and that the system's hardware platform is far more critical than the software's functionality.[1] This suggests that whenever a system's requirement can be handled by a PC application, PCs should be used. Since DEH supply operations do not require the power of a mainframe computer to run an automated supply management system, DEHs should avoid the use of mainframes.

In addition to the life-cycle costs discussed above, selecting a supply management system that is built around a commercially available, 4GL database software package offers other advantages. First, the system can undergo periodic database system improvements as they become commercially available. This ensures a minimum cost for implementing technological advances. Second, since the future of other Army and DoD information systems is not clear, it is important to remain flexible so that DEH systems can react to expected and unexpected changes.

Since modifying one of the PC-based candidates is the least-cost alternative, assuming that acquiring the software is possible and practical, we must determine which of the public- or private-sector systems will be the most cost-effective choice. Any of the candidates that were evaluated can be made to satisfy the proposed system requirements. Although the analysis showed that the effort required to modify one of the private-sector systems was actually less, some additional costs are associated

[1]An often-used rule of thumb estimates that operation and maintenance costs are three to five times as much as development costs.

with procuring and licensing any of the private-sector candidates that would not be required of the systems already owned by the Government.

Acquiring an automated system through a competitive procurement will result in additional costs and time. Since none of the private-sector systems can be purchased "off the shelf," USAEHSC would have to plan and develop a request for proposals (RFP) that clearly defines the system requirements as well as the Government's ownership rights. It is likely that the acquisition process alone would take as much as one additional year. Assuming that the costs to eventually modify the private-sector system were less than or equal to the costs to modify one of the Government-owned systems, we believe that the additional costs and time for a competitive acquisition greatly exceed any additional costs needed to modify one of the systems already owned and maintained by the Army – for example, CASTLE. Also, such acquisitions increase the risk associated with future maintenance costs and control over likely upgrades or changes. All together, the additional costs and risks associated with acquiring a private-sector system outweigh the slight benefit in functional performance.

RECOMMENDATIONS

We recommend that USAEHSC adapt an existing Government-owned PC-based supply management system such as CASTLE or, if acquiring the system proves impractical, develop a comparable system to totally comply with the proposed detailed system requirements. The candidate system should be totally compatible with IFS-M architecture (e.g., UNIX/DOS compatible), be supported by a relational-type database, and be written in a 4GL. Since CASTLE is built around a commercial, 4GL database software package, it can take advantage of periodic technological updates as they become commercially available, which ensures minimum cost for implementing these technological advances.

To guarantee that the DEH users will get a system that totally satisfies their supply management needs, we further recommend that USAEHSC reevaluate the detailed requirements phase of the system analysis process. That evaluation will ensure that all system requirements have been thoroughly identified, properly communicated to the system analysts, and well documented. A well-documented analysis minimizes the costs associated with the system design and programming phases and reduces future maintenance costs.

APPENDIX A

SYSTEM REQUIREMENTS

SYSTEM REQUIREMENTS

As the result of detailed requirements analysis conducted by a team of Army installation-level users, functional experts, and technical professionals, a set of detailed requirements for the next-generation engineering supply management system was developed. This appendix provides a brief description of each of the functional and technical criteria used to evaluate the candidate systems.

To ensure that the proposed supply management system would meet the overall future system needs of the Directorates or Division of Engineering and Housing (DEHs), several of the technical requirements were given infinite weights. Infinitely weighted criteria were considered so important to the proposed supply system configuration that any candidate system that failed to comply was dropped from further consideration. This ensures that all systems considered for replacing the Facility Engineering Supply System (FESS) would meet four important needs.

First, the new system must be on-line and interactive with the users, which reduces the time users would otherwise have to wait in a batch processing environment. In addition, this on-line interface should be user friendly and well supported by system help screens.

Second, the system must support a distributed configuration so that as many as 30 users can log onto it simultaneously. The DEH supply environment is too dynamic to expect personnel to share terminals, and storage warehouses are too vast to expect personnel to walk to a centralized computing area to make transaction inputs/outputs.

Third, the supply system must be capable of interfacing with the DEH's real property maintenance activity (RPMA) work control platform, Integrated Facilities System-Mini/Micro (IFS-M). It is critical that the two systems share information so that planners/estimators have access to the most current inventories and associated costs, that schedulers have access to current in-stock and replenishment status, that customer service representatives can accurately report the status of inventories and

job execution to DEH clients, and that resource management personnel can accurately reflect job costs which include the materials.

Fourth, the supply system must be supported by a relational-type database and standard query language (SQL). This ensures that a minimal effort will be needed to generate database queries; create management reports; and program interfaces to other DEH, Army, and DoD systems. These criteria are critical considering that the remaining parts of the Army, DoD, Government, and private industry are moving toward relational-type databases and that SQL ensures simplified communication between different systems.

TECHNICAL CRITERIA

Availability

Although "availability" was not weighted during the analytic hierarchical process (AHP) session, the IFS-M configuration control board has determined that the engineering supply management module should be in place by the beginning of 1992. That means candidate systems must be available (plus development time) by that date. Resource constraints may make this impossible, but for purposes of analysis we did not examine supply management systems that were only in the planning phase. Candidate systems had to be programmed, fully tested, and running.

On-Line Capability

The proposed supply management system must be on-line and interactive. Batch processing is not acceptable. Real-time processing is preferred but not mandatory.

Required Database Management System

This system is the heart of the proposed supply management system. The future system (and therefore the candidates) must be supported by a relational-type database together with SQL or programmed in a language that will soon be converted to be compatible with SQL. Also, the candidates must already have file maintenance programming in place. These criteria are considered essential and candidates that do not comply with these requirements will not be considered further. The requirement

for a technically supportable database management system must also include the following five components.

Relational Database/SQL

Data must be represented by a relational-type database so that the data can conform to the IFS-M architecture and ensure an open systems architecture that is totally flexible. By "relational" we mean a series of two-way tables that can be easily linked together in an infinite variety of data relationships, allowing maximum information flexibility and accessibility. SQL is the accepted national standard (and growing Army standard) for accessing data in a relational database, which once written, can be used on any hardware and any relational database software. Systems that do not comply with this requirement or are not planned for this future enhancement will not be considered further.

System Files Maintenance

The system must include utilities to file, maintain, store, retrieve, and optimize disk space. The system must also be capable of making system back-ups and restoring information.

Ease of Use/Self-Help Capability

The proposed system should be user friendly and should be supported by effective on-line help screens and windows. Help menus outside the running program will be considered noncompliant.

Canned Queries

Preprogrammed database queries that satisfy many of the supply management needs should be available.

Documentation

Candidate systems must be supported by usable documentation such as existing data dictionaries or encyclopedias, dataflow diagrams, entity-relationship diagrams, flow charts, and users manuals. Fully documented systems will ensure that system programmers understand the detailed requirements.

System Independence

The proposed system must be able to operate independently (stand alone) from other DEH and Army information systems but also must be able to satisfy required interfaces to the other Army information systems.

System Security

The candidate system must allow various levels of database and program security. Access to various system levels should be regulated by some sort of password assigned to the users.

Distributed Configuration

The proposed system must be capable of supporting local area networks with a maximum 32-user capacity and a high-speed (9,600-baud or greater) link. The proposed system must have a remote network capability of linking four to eight terminals with a high-speed (9,600 baud or greater) link. By definition, the distributed configuration assumes a simultaneous interface and remote printing capability between the host computer application and the distributed processes.

Required Interfaces

The proposed supply management system must be capable of interfacing with the five DEH and Army management information systems listed below. These interfaces must be able to readily transfer data and the information structures must be compatible. Interfaces will be partly judged on whether information can be transferred in real time or batch. Candidate systems will not be eliminated from consideration if they do not interface with the following systems, but the lowest scores will be given to those candidate systems that are incapable of interfaces and higher scores given to the candidates that are capable of these interfaces. Total compliance means that export/import routines that will readily transfer the required data are already programmed.

IFS-M

Candidate systems must be capable of interfacing with the IFS-M. Since IFS-M is the umbrella system under which the supply system will operate, candidates that cannot interface will not be considered further. For that reason, the candidate system must operate in a UNIX or disk operating system (DOS) environment. IFS-M

already has interfaces programmed to the other Army information systems and can serve as a gateway between them and the supply management system. However, not all Army installations are implementing IFS-M and these interfaces are essential for those installations.

Standard Army Automated Contracting System (SAACONS)

The proposed supply management system must be capable of interfacing with the Army's proposed automated contracting system, SAACONS.

Other Supply Information

Interfaces with other supply information systems such as "Partmaster" and/or "Haystack" should already be written.

SAILS/SARSS

The candidate systems must be capable of interfacing with the Standard Army Intermediate Level Supply (SAILS) system and the Standard Army Retail Supply System (SARSS) or their successors.

Finance and Accounting

The candidate supply management system must be able to export the required data to the Army's finance and accounting system.

Platform Independence

Since system hardware has not yet been determined, the candidate system software must be capable of operating on standard mini- or microcomputers (highly flexible portability). Also, selecting a platform-independent system will guarantee that DEH systems maintain an open-architecture environment and will ensure the system remains flexible. Therefore, the candidate system must be programmed in portable application languages. Platform independence also assumes that the system will operate under a normal office environment with little renovation for heating, ventilating, and air conditioning (HVAC) or electrical equipment. Some minor remodeling may be necessary for physical security of the system.

Scanning Capabilities

The proposed engineering supply management system must be capable of utilizing current and future scanning technologies. Systems that are not capable of such hardware compatibility are not flexible enough for further consideration. How well the candidate system allows scanning inputs dictates the score they receive for the following categories.

Bar-Code Inputs

The proposed system must be capable of accepting bar-code inputs either directly from bar-coding hardware or downloaded from this equipment in a batch mode. Bar coding will be extremely important for most aspects of material receipt, issue, and inventory control.

Optical Scanning Equipment

The candidate systems should be able to accept inputs pertaining to order issues and order receipts from optical scanning equipment.

Imaging

The future engineering supply management system must be capable of storing and retrieving electronically stored images. Being able to generate pictures – on terminals or hard copy – will be a tremendous advantage to the engineering supply operations.

FUNCTIONAL CRITERIA

Report Generating and Printing Capabilities

Given the infinitely weighted requirement for a relational database and SQL, the system's ability to comply with any single reporting requirement would be minimal. Compliance with this requirement will be based on the candidate system's ability to easily search and sort user-selected elements of the database and to generate flexible reports such as supply management reports, reorder reports, stock number history reports, audit transaction reports, overestimate reports, due-out/due-in reports, zero balance reports, and transfer lists, to name a few.

Stock Control Requirements

The proposed engineering supply management system must be capable of the following stock control functions.

Expanded Item Identification

The system should have an expanded item identification field to further identify inventory items. Users need the capability to search for inventory items by nomenclature, part number, physical characteristics, and substitute items.

Stock Fund War Reserves/Freeze Codes

The system should be able to electronically reserve inventory items tagged for war reserves or other needs. This is particularly important where DEHs share warehouse space and need inventory dedicated to their specific requirements. This will ensure materials will be available for RPMA when needed.

Catalog File

The system should be able to generate an up-to-date catalog of all inventoried items including quantities, description, substitutes, location, and order status. The catalog should be on-line but it should also be easy to generate hard copy.

Replenishment Capability

The proposed system must be capable of generating an inventory replenishment on demand or at a specified reorder point using any accepted economic order quantity (EOQ) algorithm. This capability should be easily modified to satisfy the needs of different installations. Inventory control should consider holding costs, ordering costs, etc.

Add/Drops

The system should identify items of inventory that should be added as stocked items and those that should be removed from stock items based on demand or other criteria.

Physical Inventory Requirements

The proposed engineering supply management system must be capable of the following physical inventory functions.

Cyclic Inventories

The candidate system should be capable of inventorying all or part of the material in the warehouse yearly or at any interval at the discretion of the warehouse managers.

Inventory Worksheet

The system must be able to generate inventory worksheets that satisfy different DEH needs.

Line-Item/Dollar-Value Accounting

The system must be able to count inventory by line item or accumulate it by dollar value. This function must be on-line and must reflect the most current information.

Seasonal/Standby Items

The proposed system must be able to handle seasonal/standby items of inventory in addition to normal demand criteria.

Spoilage/Aging Inventory Display

The system should be capable of tracking the length of time items of inventory – individual pieces or lots – have been in the system to determine aging and spoilage of those items.

Picking/Issuing Requirements

The proposed engineering supply management system must be capable of performing the following inventory picking/issuing functions.

Creates Pick Documents

The system must be able to generate flexible pick documents needed by material coordinators and shop foremen.

Automatic Material Coordination and Equipment Control

Items of inventory must be tracked when they are being held in the material coordination area. The proposed system must able to track these materials at storage sites, maintain data issued information, and keep accountable records. It must keep those records separate from the stock fund account.

Automated Issue/Return Slips

The system must be capable of handling automated issue/return slips such as the material release orders.

Determining Picking Criteria

The system must be capable of determining the criteria for picking inventory and planning how it is to be picked.

Receiving/Putaway Requirements

The proposed engineering supply management system must be capable of performing the following inventory receiving/putaway functions.

Generating Storage Documents

The system must generate various types of storage documents that offer flexibility to individual users.

Hot Tag (Receipt/Issue)

This requirement refers to the ability to monitor demand of items that have yet to be received. When items in demand are received, they are not stored but are immediately issued/shipped.

Partial Receipts

The system must be able to handle partial receipt of ordered material and reconcile the quantity received versus quantity ordered.

Automatic Inventory Update

Inventory levels must automatically be updated as inventory is received and issued.

Discrepant Material

The system must be capable of reconciling differences in material received versus material ordered. The system should make necessary adjustments to stock files and process paperwork for items returned to the wholesale depot or local vendor as well as all necessary cost accounts.

Order Processing Requirements

The proposed engineering supply management system must be capable of performing the following order processing functions.

Transaction Reversal Capability

The system must be capable of transaction reversals so that erroneous entries or changes can be easily corrected while on line. The user should not have to leave the system to make the reversals, but transactions should be recorded.

Document Register

The system must be able to support a dynamic electronic log of documents in the system that contain updated transaction status.

Military Standard Requisitioning and Issue Procedures

The system must support both current and future military standard requisitioning and issue procedures (MILSTRIP).

Transaction Register

Candidate systems must be able to maintain a history of all system transactions and must be able to support an audit trail of such transactions.

Automatic Purchase Requisitions

The system should be capable of generating automatic purchase requisitions electronically when items reach their reorder point.

Reconciliation

The system must be capable of reconciling open orders at the wholesale level with receipts at the retail level.

Job Cost by Document, Phase, and/or Facility

The system must be able to collect costs by document, phase, and/or facility and report them by export routines to other systems such as the finance and accounting system or by generating hard-copy management reports. The system must be sophisticated enough to allocate costs to various accounts and costing structures.

APPENDIX B

SYSTEM COMPLIANCE SUMMARY

SYSTEM COMPLIANCE SUMMARY

TABLE B-1

SYSTEMS COMPLIANCE SUMMARY

System requirements	Weight	Score										
		MEDSTOC	APPMS	AMCISS	BOSS	WIS	CASTLE	CEMAS	SBSS	EPOS	FESS	SARSS
Technical criteria												
On-line capability	∞	2	5	5	5	5	5	4	3	5	5	5
Required database management system												
Relational database/SQL	∞	0	5	3	0	4	4	0	0	4	0	5
System files maintenance	∞	4	5	5	4	4	5	4	4	5	4	4
Ease of use/self-help capability	0 143	2	4	2	2	3	5	3	2	4	2	3
Canned queries	0 011	4	3	4	4	3	4	3	3	4	4	5
Documentation	0 033	4	3	4	4	4	4	3	3	3	4	2
System independence	0 071	5	5	5	5	5	5	2	3	5	4	5
System security	0 024	4	4	4	4	4	4	3	3	4	5	4
Distributed configuration	∞	0	5	1	3	5	5	2	1	5	5	5
Required interfaces												
IFS-M	∞	3	4	2	3	4	4	2	2	4	3	4
SAACONS	0 048	3	4	4	3	4	4	2	2	3	3	4
Other supply information	0 019	3	3	4	3	3	3	2	2	3	3	4
SAILS/SARSS	0 007	4	4	4	3	3	3	2	2	3	4	4
Finance and accounting	0 136	4	4	4	3	4	4	2	3	4	4	4
Platform independence	0 368	0	5	0	0	5	5	2	0	5	0	4
Scanning capabilities												
Bar-code inputs	0 028	1	5	4	2	2	5	2	1	5	2	5
Optical scanning equipment	0 028	1	2	1	2	1	3	2	1	3	2	2
Imaging	0 083	1	2	1	2	1	3	2	1	3	2	2
Weighted total		1 83	4 18	1 98	1 82	3 87	4 47	2 21	1 40	4 25	1 92	3 68
Functional criteria												
Report generating and printing capabilities	0 035	4	5	4	3	3	5	3		2	3	5
Stock control requirements												
Expanded item identification	0 022	2	4	4	5	4	4	2		3	1	5
Stock fund war reserves/freeze codes	0 01	5	1	5	5	3	4	4		3	1	5
Catalog file	0 114	4	4	4	4	4	4	4		4	4	4
Replenishment capability	0 093	5	1	3	5	2	3	4		4	4	5
Add/drops	0 021	5	2	5	5	2	3	4		4	5	5

Note. All acronyms are defined on p B-4

TABLE B-1

SYSTEMS COMPLIANCE SUMMARY (Continued)

System requirements	Weight	Score										
		MEDSTOC	APPMS	AMCISS	BOSS	WIS	CASTLE	CEMAS	SBSS	EPOS	FESS	SARSS
Physical inventory requirements												
Cyclic inventories	0.003	4	2	5	5	5	5	5		5	1	5
Inventory worksheet	0.025	5	3	5	4	3	5	4		3	5	4
Line-item/dollar-value accounting	0.028	5	4	5	5	4	5	4		5	5	5
Seasonal/standby items	0.013	5	1	5	5	3	4	2		5	1	5
Spoilage/aging inventory display	0.003	5	3	5	3	1	4	1		3	1	5
Picking/issuing requirements												
Creates pick documents	0.007	1	1	4	4	1	5	4		4	5	5
Automatic material coordination and equipment control	0.028	2	1	3	3	2	2	3		1	1	1
Automated issue/return slips	0.052	3	3	4	3	1	5	1		2	3	4
Determining picking criteria	0.003	1	1	2	1	1	1	1		1	1	1
Receiving/putaway requirements												
Generating storage documents	0.0[illegible]	4	1	4	4	1	4	1		3	5	5
Hot tag (receipt/issue)	0.01	5	5	5	4	3	3	4		1	3	3
Partial receipts	0.018	4	1	4	4	3	4	4		4	1	5
Automatic inventory update	0.048	5	5	4	5	4	5	5		5	5	5
Discrepant material	0.004	5	2	4	2	1	4	3		4	1	4
Order processing requirements												
Transaction reversal capability	0.012	5	5	4	4	5	5	4		4	1	5
Document register	0.006	4	5	4	4	4	5	4		4	1	5
MILSTRIP procedures	0.052	5	4	5	5	1	5	4		4	5	5
Transaction register	0.024	4	5	5	4	4	5	5		5	5	3
Automatic purchase requisitions	0.063	1	3	4	1	1	3	3		4	1	4
Reconciliation	0.009	4	1	4	4	1	4	2		3	1	3
Job cost by document, phase, and/or facility	0.288	1	2	4	4	2	4	4		3	4	2
Weighted total		3.24	2.92	4.26	4.19	2.57	4.20	3.79	0.00	3.61	3.68	3.89

Note. MEDSTOC = Medical Stock Control System, APPMS = Automated Personal Property Management System, AMCISS = AMC Installation Supply System, BOSS = Base Operations Support System. WIS = Warehouse Inventory Control System, CASTLE = Computer-Aided Supply Transactions, Logistics Environment, CEMAS = Civil Engineering Material Acquisition System. SBSS = Standard Base Supply System, EPOS = Electronic Point-of-Sale, FESS = Facility Engineering Supply System, IFS-M = Integrated Facility System-Mini/Micro. SQL = Standard Query Language. SAACONS = Standard Army Automated Contracting System, SAILS = Standard Army Intermediate Level Supply. SARSS = Standard Army Retail Supply System. MILSTRIP = military standard requisitioning and issue procedure

APPENDIX C

ESTIMATED MODIFICATION EFFORT (MAN-DAYS)

ESTIMATED MODIFICATION EFFORT (MAN-DAYS)

TABLE C-1

ESTIMATED MODIFICATION EFFORT

(Man-days)

System requirements	Score							
	APPMS	AMCISS	BOSS	WIS	CASTLE	EPOS	FESS	SARSS
Technical criteria								
On-line capability	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Required database management system	–	–	–	–	–	–	–	–
Relational database/SQL	Pass	Fail	Fail	Pass	Pass	Fail	Pass	Pass
System files maintenance	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Ease of use/self-help capability	22	88	88	33	0	22	132	66
Canned queries	22	44	44	22	22	22	22	22
Documentation	22	66	66	22	22	44	66	132
System independence	0	0	0	0	0	0	0	0
System security	6	22	22	6	0	11	0	11
Distributed configuration	Pass	Fail	Fail	Pass	Pass	Pass	Pass	Pass
Required interfaces	44	132	198	44	0	88	132	22
IFS-M	Pass	Fail	Fail	Pass	Pass	Pass	Fail	Pass
SAACONS	–	–	–	–	–	–	–	–
Other supply information	–	–	–	–	–	–	–	–
SAILS/SAARS	–	–	–	–	–	–	–	–
Finance and accounting	–	–	–	–	–	–	–	–
Platform independence	0	0	0	0	0	0	0	0
Scanning capabilities								
Bar-code inputs	0	66	66	0	0	0	44	0
Optical scanning equipment	44	88	88	44	22	22	44	88
Imaging	66	132	132	66	44	66	88	132
Technical effort	226	638	704	237	110	275	528	473

Note All acronyms are defined on page C-5. columns may not add due to rounding

TABLE C-1

ESTIMATED MODIFICATION EFFORT (Continued)

(Man-days)

System requirements	Score							
	APPMS	AMCISS	BOSS	WIS	CASTLE	EPOS	FESS	SARSS
Functional criteria								
Report generating and printing capabilities	0	88	132	22	0	33	44	0
Stock control requirements								
Expanded item identification	6	44	0	6	6	11	66	0
Stock fund war reserves/freeze codes	6	0	0	6	0	6	11	0
Catalog file	11	66	66	11	0	44	66	44
Replenishment capability	22	44	0	22	1	6	11	0
Add/drops	11	0	0	6	1	6	11	0
Physical inventory requirements								
Cyclic inventories	44	0	0	6	0	0	44	0
Inventory worksheet	6	0	22	6	0	11	0	11
Line-item/dollar-value accounting	11	0	0	11	0	0	0	0
Seasonal/standby items	11	0	0	6	0	0	11	0
Spoilage/aging inventory display	11	0	66	17	6	17	22	0
Picking/issuing requirements								
Creates pick documents	33	66	66	22	6	33	66	66
Automatic material coordination and equipment control	–	–	–	–	–	–	–	–
Automated issue/return slips	–	–	–	–	–	–	–	–
Determining picking criteria	–	–	–	–	–	–	–	–
Receiving/putaway requirements	22	88	88	22	11	44	66	22
Generating storage documents								
Hot tag (receipt/issue)	–	–	–	–	–	–	–	–
Partial receipts	–	–	–	–	–	–	–	–
Automatic inventory update	–	–	–	–	–	–	–	–
Discrepant material	–	–	–	–	–	–	–	–

Note All acronyms are defined on page C-5; columns may not add due to rounding.

TABLE C-1

ESTIMATED MODIFICATION EFFORT (Continued)

(Man-days)

System requirements	Score							
	APPMS	AMCISS	BOSS	WIS	CASTLE	EPOS	FESS	SARSS
Order processing requirements								
Transaction reversal capability	0	22	22	0	0	11	44	0
Document register	0	11	11	6	0	6	33	0
MILSTRIP procedures	11	0	0	22	0	11	0	0
Transaction register	0	0	11	6	0	0	0	22
Automatic purchase requisitions	11	22	44	11	6	11	44	11
Reconciliation	6	11	11	6	0	11	33	22
Job cost by document, phase, and/or facility	11	22	22	11	0	22	44	44
Functional effort	231	484	561	220	35	281	616	242
Total modification effort	457	1,122	1,265	457	145	556	1,144	715

Note. MEDSTOC = Medical Stock Control System, APPMS = Automated Personal Property Management System, AMCISS = AMC Installation Supply System, BOSS = Base Operations Support System, WIS = Warehouse Inventory Control System, CASTLE = Computer-Aided Supply Transactions, Logistics Environments, CEMAS = Civil Engineering Material Acquisition System, SBSS = Standard Base Supply System, EPOS = Electronic Point of Sale, FESS = Facility Engineering Supply System, IFS-M = Integrated Facility System-Mini/Micro, SQL = Standard Query Language, SAACONS = Standard Army Automated Contracting System, SAILS = Standard Army Intermediate Level Supply, SARSS = Standard Army Retail Supply System, MILSTRIP = military standard requisitioning and issue procedure

Columns may not add due to rounding

APPENDIX D

GLOSSARY

GLOSSARY

ABECAS	=	Argos Business Enterprise Cost Accounting System
AHP	=	analytic hierarchical process
AMC	=	Army Materiel Command
AMCISS	=	Army Materiel Command Installation Supply System
ANSI	=	American National Standards Institute
APPMS	=	Automated Personal Property Management System
ASCII	=	American Standard Code for Information Interchange
ASIMS	=	Army Standard Information Management System
BCE	=	Base Civil Engineer
BOSS	=	Base Operations Support System
CASCOM	=	Combined Arms Support Command
CASTLE	=	Computer-Aided Supply Transactions, Logistics Environment
CEMAS	=	Civil Engineering Material Acquisition System
CERL	=	Construction Engineering Research Laboratory
COBOL	=	common business oriented language
DEH	=	Directorate of Engineering and Housing
DLA	=	Defense Logistics Agency
DoD	=	Department of Defense
DOL	=	Directorate of Logistics
DOS	=	disk operating system
EOQ	=	economic order quantity
EPOS	=	Electronic Point of Sale
FEJE	=	Facilities Engineering Job Estimating System

FESS	=	Facilities Engineering Supply System
HSC	=	Health Services Command
IBM	=	International Business Machines
IFDEP	=	Integrated Facilities Data Entry Process
IFS-M	=	Integrated Facilities System-Mini/Micro
LMI	=	Logistic Management Institute
MEDSTOC	=	Medical Stock Control System
MILSTRIP	=	Military Standard for Requisitioning and Issue Procedures
PC	=	personal computer
RFP	=	request for proposals
RPMA	=	real property maintenance activity
SAACONS	=	Standard Army Automated Contracting System
SARSS	=	Standard Army Retail Supply System
SBSS	=	Standard Base Supply System
SQL	=	standard query language
SAILS	=	Standard Army Intermediate Level Supply System
STANFINS	=	Standard Army Financial System
USAEHSC	=	U.S. Army Engineering and Housing Support Center
WIS	=	Warehouse Inventory Control System

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13. ABSTRACT ***(Maximum 200 words)***

The U.S. Army Engineering and Housing Support Center (USAEHSC) is modernizing the Facility Engineering Supply System (FESS) used by those Directorates or Divisions of Engineering and Housing (DEHs) that managed real property maintenance supplies in house. The decision to upgrade FESS is based on the inability of the software to satisfy current system requirements, high yearly maintenance costs, and outdated system hardware.

We found that the lowest life-cycle cost alternative for modernizing the FESS is to modify an existing personal computer (PC) based system already owned by the Army, or under certain circumstances, to develop an entirely new system. The additional costs to procure and license an existing private sector system far exceed any functional advantages and any alternative that ports or upgrades existing FESS software to a new platform is not cost-effective. Adopting a PC based system has the added benefit of improved system expandability, flexibility, and better control.

We recommend that USAEHSC take the following actions to minimize the life cycle costs of implementing the next-generation supply management system used by DEHs.

- Adapt an existing PC based supply management system or, if acquiring an existing system proves impractical, develop a comparable system that is compatible with UNIX and disk operating system (DOS) environments, supported by a relational type database and standard query language, and written in a fourth-generation programming language. The Corps of Engineers Computer Aided, Supply Transaction, Logistics Environment is an example of an existing system that USAEHSC should modify.
- Complete a detailed requirements analysis of the proposed system to ensure the next generation system fully supports the Army's needs, design and program the system, and implement it in a timely manner to minimize costs.

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